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UNITED STATES
DEPARTMENT OF THE INTERIOR
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QUARRYING METHODS AND PRACTICES
U. S. LIME PRODUCTS CORP.
CLARK COUNTY, NEV.

BY

GEORGE H. HOLMES, JR.

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QUARRYING METHODS AND PRACTICES, U. S. LIME PRODUCTS CORP., CLARK COUNTY, NEV.[1]

By George H. Holmes, Jr.[2]

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[1] Work completed January 1949. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7517."

[2] Mining engineer, Reno Branch, Mining Division, Bureau of Mines, U. S. Department of the Interior.

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INTRODUCTION

This paper is one of a series on mining methods and practices published by the Bureau of Mines. It describes quarrying methods and crushing practices of the U. S. Lime Products Corp. at its Sloan and Apex quarries. Calcining and milling processes at the Sloan and Henderson plants also are outlined.

The Sloan dolomite and limestone quarries and plant are in secs. 12 and 13, T. 23 S., R. 60 E., and sec. 18, T. 23 S., R. 61 E., M.D.B.&M., Clark County, Nev., about 17 miles by paved highway southwest of Las Vegas (fig. 1).

The Apex limestone quarry and crushing plant are in sec. 26, T. 18 S., R. 63 E., M.D.B.&M., Clark County, Nev., approximately 18 miles northeast of Las Vegas, adjacent to U. S. Highway 91 (fig. 1).

The Henderson calcining plant is in a reduction unit of Basic Magnesium, Inc., in sec. 13, T. 22 S., R. 62 E., M.D.B.&M., Clark County, Nev., about 14 miles southeast of Las Vegas on U. S. Highway 93 (fig. 1).

ACKNOWLEDGMENTS

Acknowledgment is made to the U. S. Lime Products Corp., 1840 E. 25th Street, Los Angeles, Calif., for permission to publish this information. Special acknowledgment is due K. E. Ellsworth, vice-president; L. N. Grindell, resident manager; William Ellis, mill superintendent; and William Brown, quarry superintendent, for their cooperation in supplying data on methods and costs and their assistance in preparing this manuscript.

HISTORY

The Sloan high-calcium limestone deposit was discovered about 1910, and quarrying began a few years later to supply the lime requirements of the mills at Tonopah and Goldfield for the cyanide treatment of gold and silver ores. Upon the decline of the gold-mining districts, new markets were found in the steel mills and sugar refineries of southern California.

The property was operated by the Nevada Lime & Rock Corp. until 1927, when it was purchased by the U. S. Lime Products Corp., the present owners.

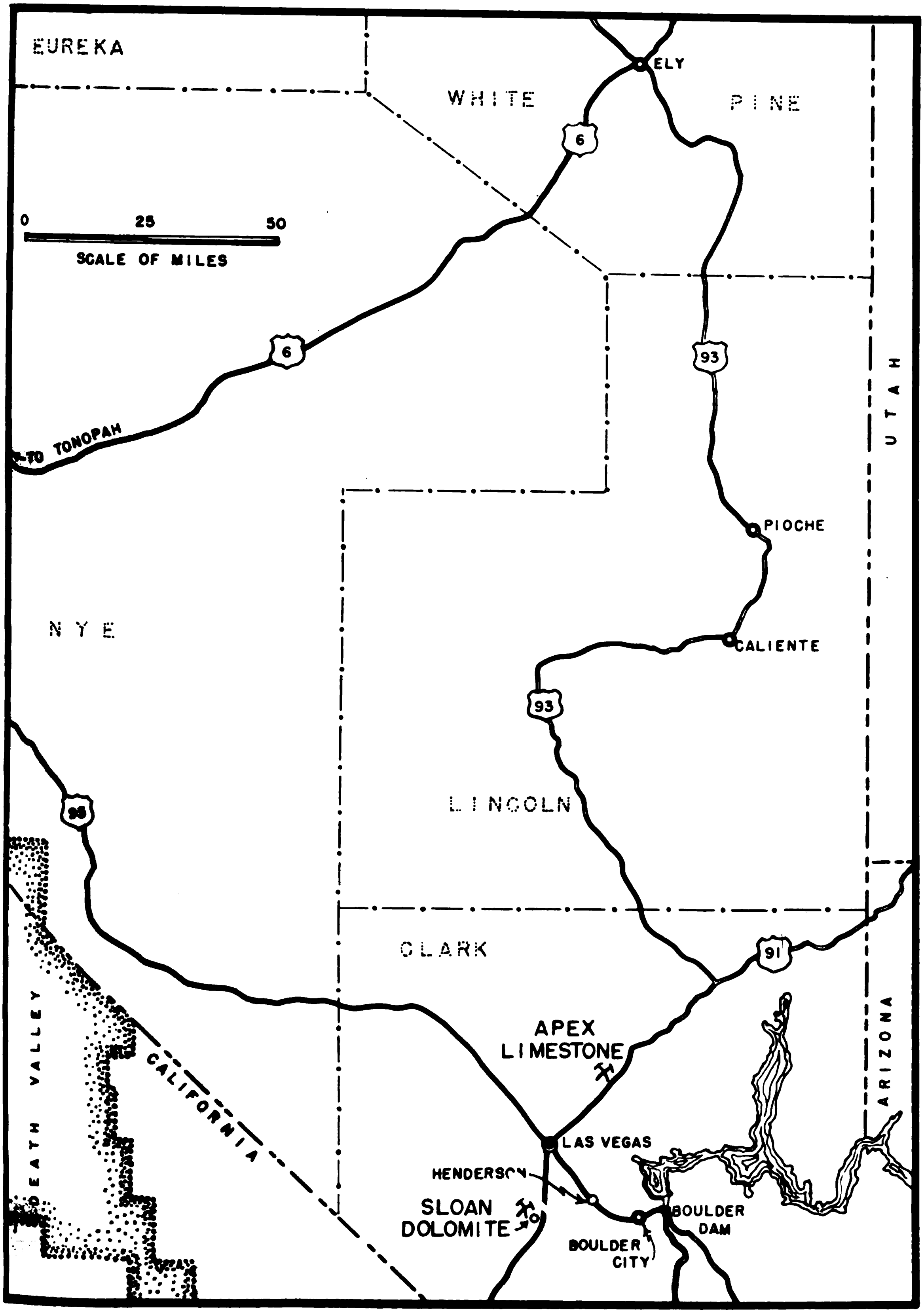

Figure I. - Location map of U. S. Lime Products Corp. properties, Clark County, Nev.

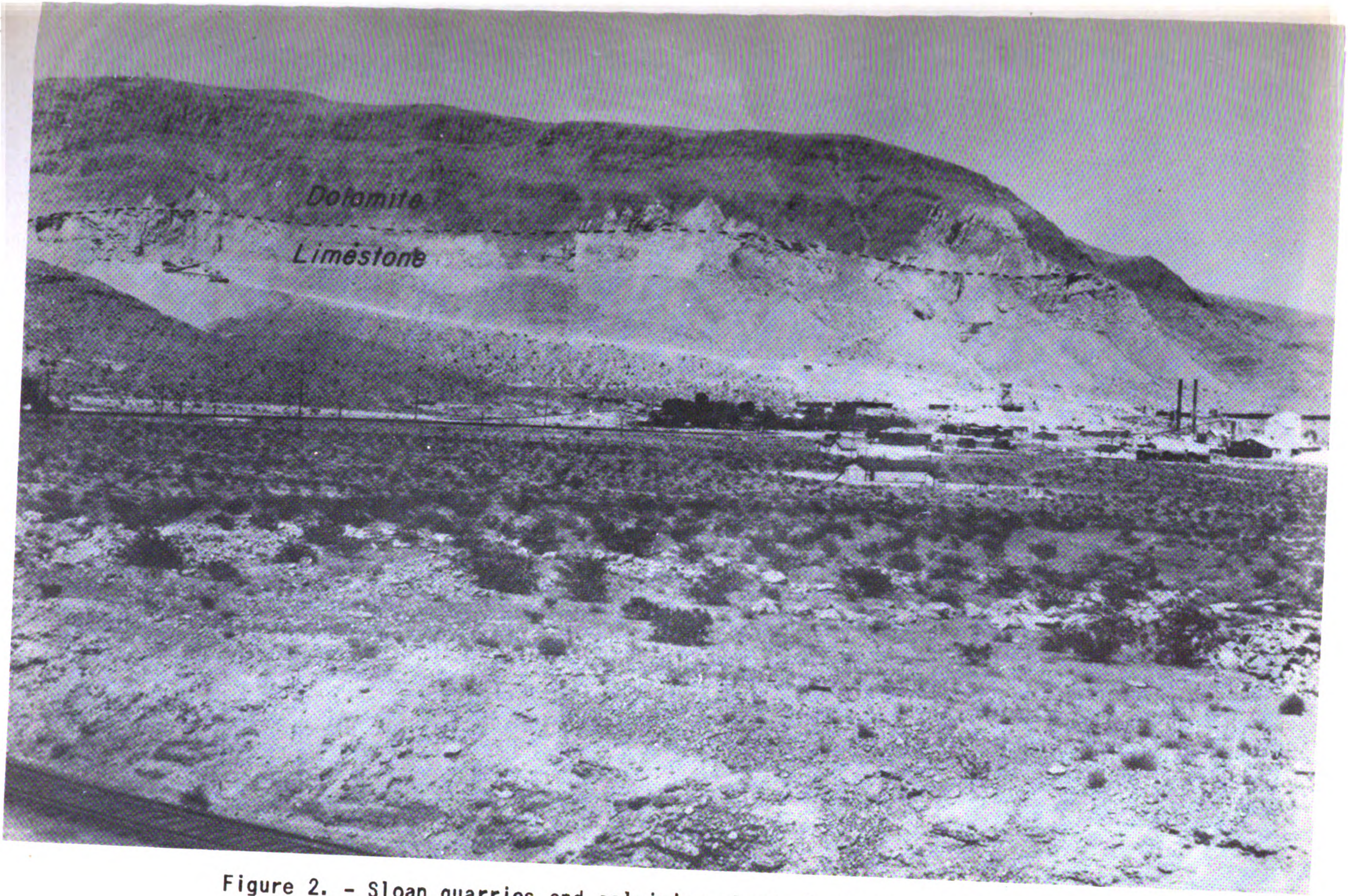

Figure 2. - Sloan quarries and calcining plant, U. S. Lime Products Corp.

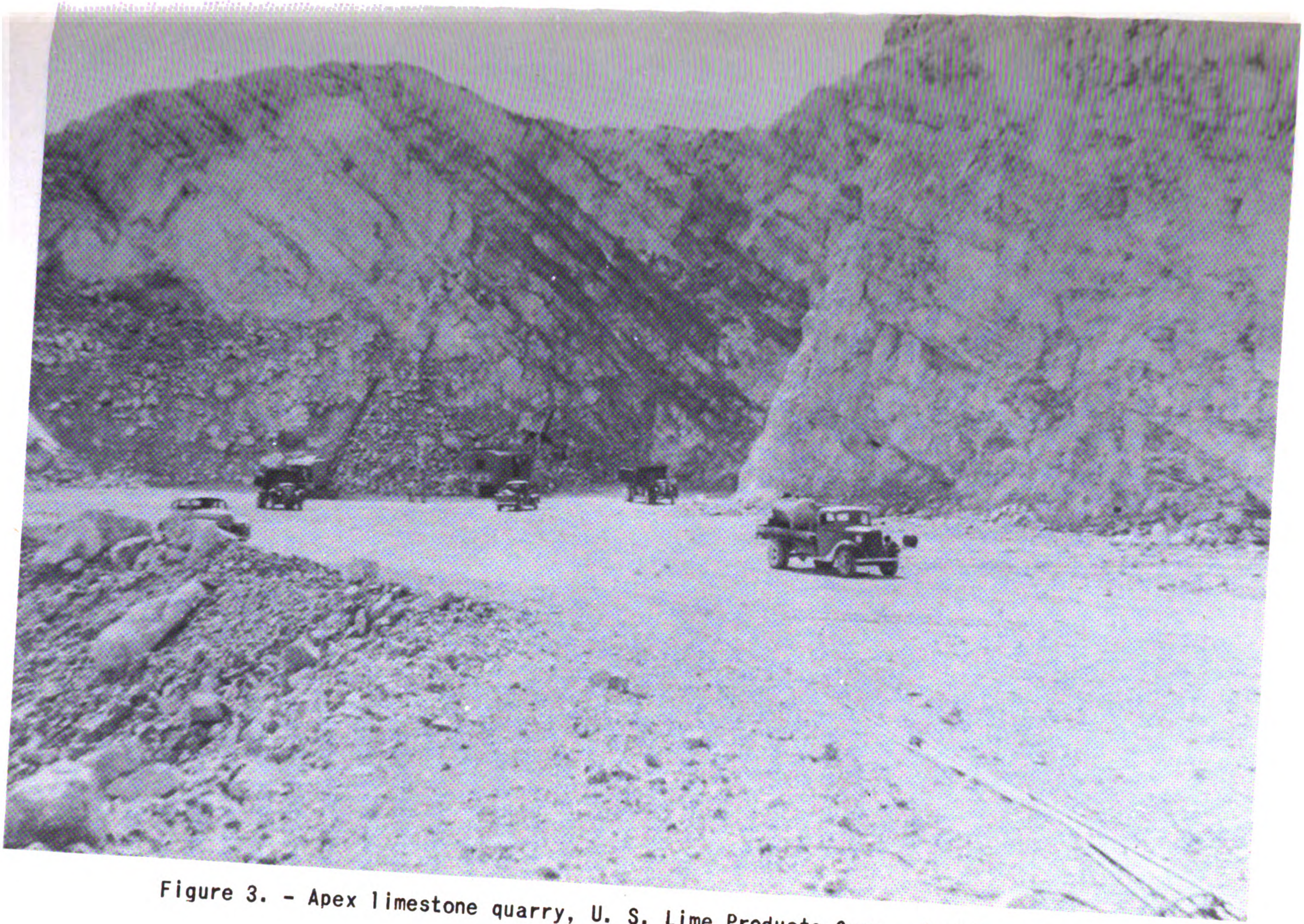

Figure 3. - Apex limestone quarry, U. S. Lime Products Corp., looking south.

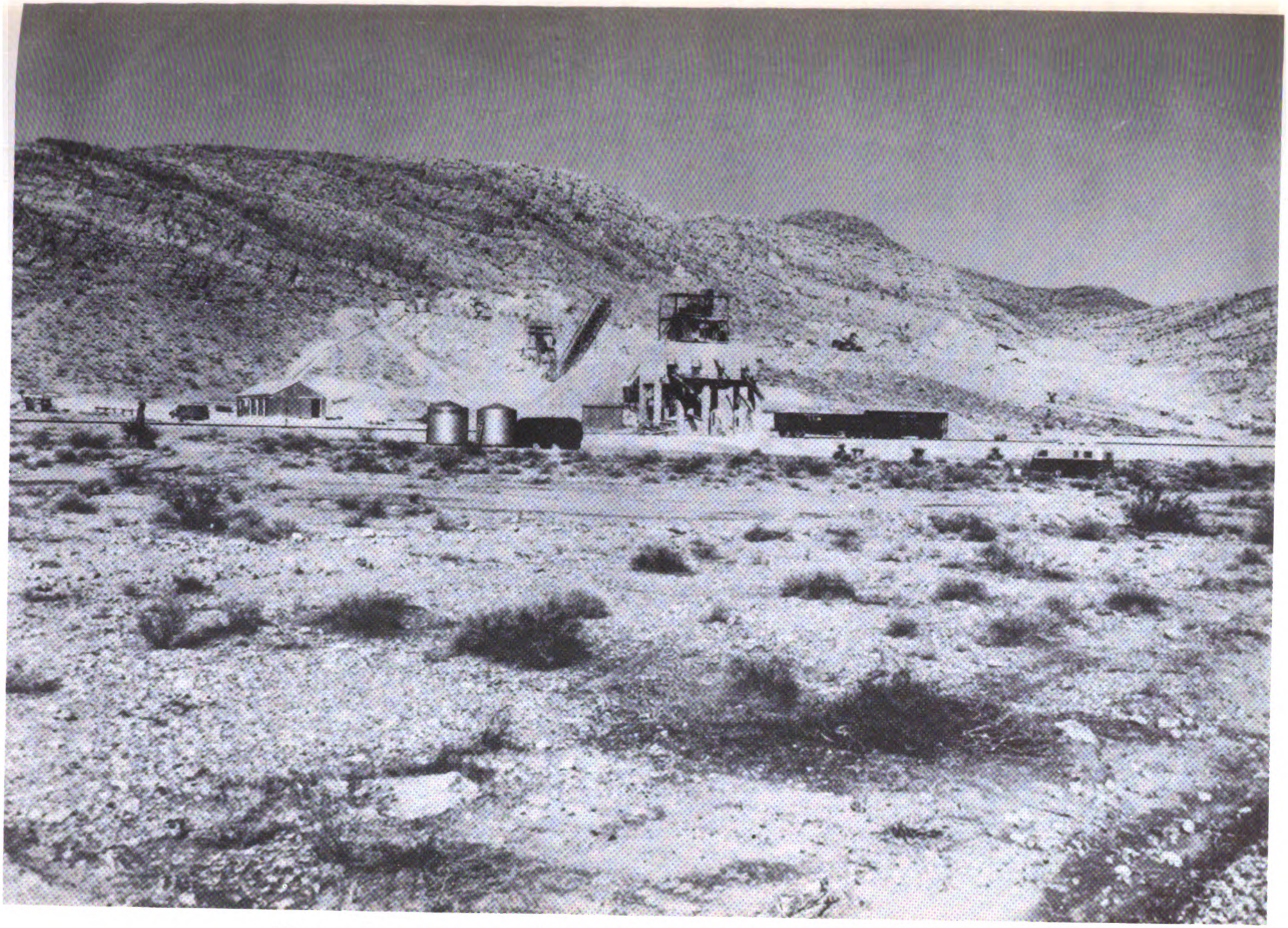

Figure 4. - Apex crushing plant, U. S. Lime Products Corp.

The beds of dolomite that lie above the limestone were not considered of potential commercial value prior to acquisition by the present company. Subsequent investigations resulted in the installation of three vertical kilns for calcining the dolomite. Production has been continuous since 1928.

Quarrying of limestone from the Sloan deposit was suspended in 1946 primarily because of dilution with overlying dolomite and high costs of underground mining.

Claims that had been located on limestone beds at Apex, 18 miles northeast of Las Vegas, were taken over by the company in 1943, and exploration by diamond drilling was begun two years later. This work proved the existence of large deposits of commercial limestone. The deposit was subsequently prepared for quarrying, and a crushing and screening plant was erected. Production began in 1946, and the company's entire limestone production now comes from this quarry. Estimated production from the Sloan limestone and dolomite deposits through 1947 exceeded two million tons.

PHYSICAL FEATURES AND COMMUNICATIONS

A semi-arid climate prevails in this section of southern Nevada, with hot summers and moderate winters. Precipitation is scant, the annual fall averaging less than 4.5 inches.

The quarries at Sloan are on the southwest side of a steeply rising hill, which attains an altitude of 3,800 feet. The calcining plant and the town of Sloan are about a quarter of a mile south from the base of the hill, at an altitude of 2,800 feet (fig. 2). U. S. Highway 91 passes about a mile east of Sloan, and the main line of the Union Pacific Railroad runs through the property. Short spurs run to the loading and storage bins.

The Apex quarry and crushing plant are on the east side of a low hill at an altitude of about 2,300 feet (figs. 3 and 4). U. S. Highway 91 and the main line of the Union Pacific Railroad pass a quarter of a mile east of the property. A short spur connects the loading bins with the main line.

U. S. Highway 93 passes about a mile north of the Henderson plant. Crushed rock and calcined products are transported over a branch of the Union Pacific Railroad.

The high-calcium limestone is transported via Union Pacific Railroad from the Apex quarry to Sloan and Henderson for calcining. The present freight charge to these plants is $0.73 per ton.

There are telephone and telegraph facilities at Henderson and telegraph facilities at Sloan.

UTILITIES

Power

Although the Apex and Sloan plants are close to Hoover Dam transmission lines, cheaper power has been generated with Diesel generators. Company records indicate that generated power costs averaged approximately $0.01 per kilowatt-hour prior to 1941, compared to a peak-load charge, at the same time, of $0.0125 to $0.0150 per kilowatt-hour for transmission-line power.

Advances in the price of Diesel oil and maintenance, labor, and material costs are rapidly changing this differential. The company is reviewing the power situation, which may result in changing over to transmitted power at the Sloan and Apex plants.

Diesel oil is supplied in tank cars at a delivered cost of $0.115 a gallon at Sloan and $0.12 a gallon at Apex. The prewar delivered price of Diesel oil at Sloan was $0.0525 a gallon. Fuel oil for the calcining plant is delivered in tank cars at a cost of $0.085 a gallon, f.o.b. Sloan.

Power at Sloan is 3-phase, 60-cycle, 440-volt supplied by 30-kw., 72-kw., and 75-kw., Diesel-driven, electric generators. Apex power is produced by an interconnected battery of two 30-kw. and two 50-kw. Diesel generators. The Henderson calcining plant is supplied with transmission-line power.

Water

Water is supplied to the Sloan camp and plant from a 600-foot well drilled near the mine. Water was encountered at 520 feet, and pumping is at a 2,400-gallon-hourly rate. The water has a high lime content and is distilled for use in the power-plant cooling system to prevent deposition of scale.

Water for the Apex plant is hauled to the property in railroad tank cars and is stored in two 10,000-gallon tanks. A series of wells supplies water to Henderson and the industries in the Basic Magnesium, Inc., plant.

POWER EQUIPMENT

The Sloan power plant is housed in mill buildings and comprises:

1 Caterpillar-Diesel, Model D4600, 30-kw. generator.
1 120-h.p. Fairbanks-Morse, 2-cylinder, vertical Diesel, type Y-V-A, direct-connected to a 72-kw. generator.
1 150-h.p., Fairbanks-Morse, 2-cylinder, vertical Diesel, Model 32E14, belt-connected to a 75-kw. generator.

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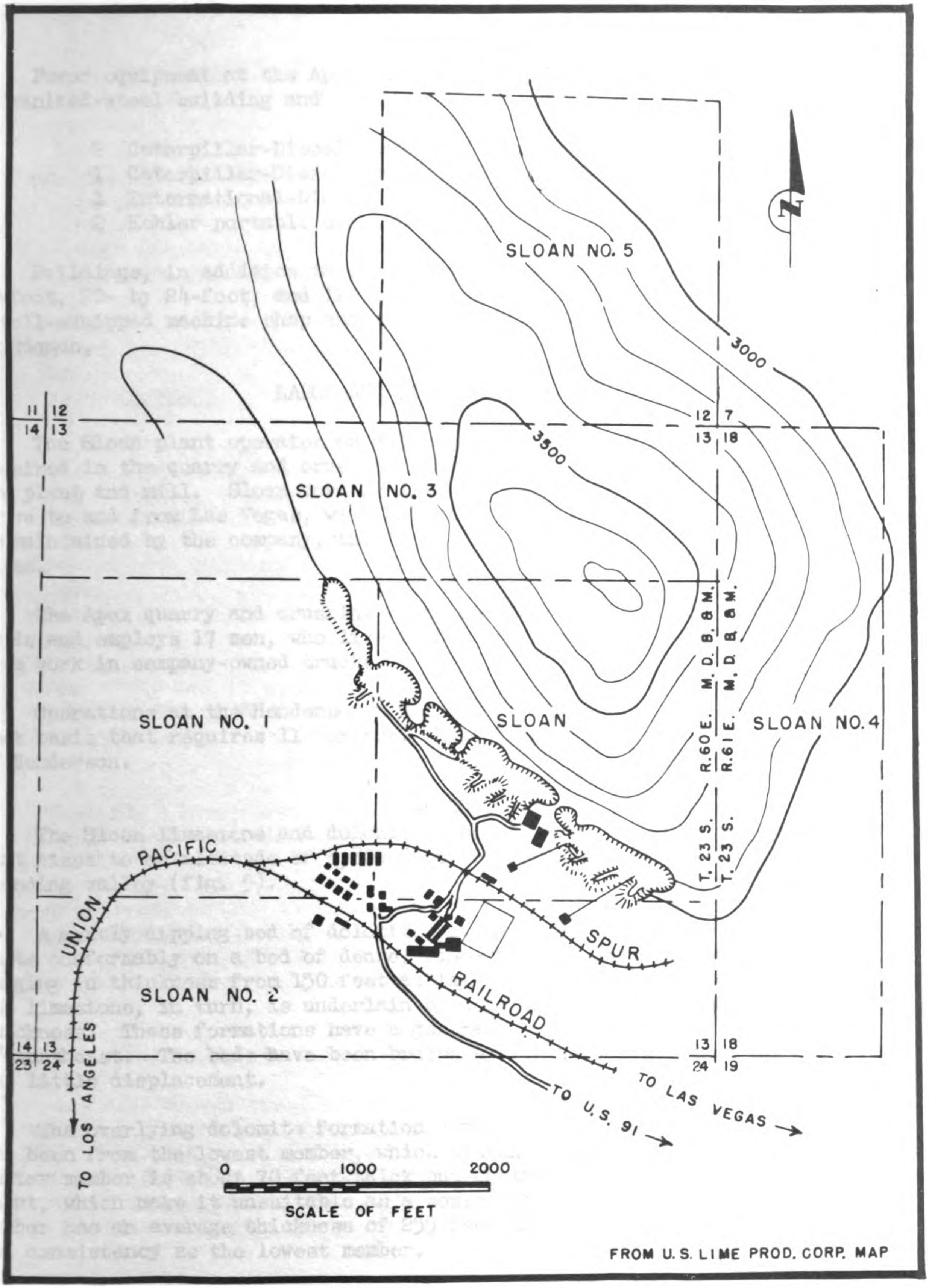

FROM U. S. LIME PROD. CORP. MAP

Figure 5. - Plan map of Sloan deposit, U. S. Lime Products Corp.

Power equipment at the Apex plant is housed in a 20- by 56-foot, galvanized-steel building and consists of:

2 Caterpillar-Diesel, Model D4600, 30-kw. generators.
1 Caterpillar-Diesel, Model D8800, 50-kw. generator.
1 International-Diesel, Model UD18, 50-kw. generator.
2 Kohler portable electric generators - light plants.

Buildings, in addition to the power house at Apex, comprise a 24- by 60-foot, 20- by 24-foot, and 12- by 24-foot Quonset buildings, which house a well-equipped machine shop and garage, a warehouse, and a watchman's residence.

LABOR AND LIVING CONDITIONS

The Sloan plant operates on a 3-shift basis 7 days a week. Ten men are required in the quarry and crushing plant, and 32 workmen operate the calcining plant and mill. Sloan workers live in company-owned cottages or they drive to and from Las Vegas, with allowances for travel time. A commissary is maintained by the company, and there is a postoffice and grade school at Sloan.

The Apex quarry and crushing plant operates on a one-shift, 5-day-week basis and employs 17 men, who live in Las Vegas and are transported to and from work in company-owned trucks.

Operations at the Henderson plant are on a continuous 3-shift, 7-day-week basis that requires 11 workers. Employees live in the adjacent town of Henderson.

GEOLOGY

The Sloan limestone and dolomite deposits occur in an isolated mountain that rises to an altitude of 3,800 feet, or about 1,000 feet above the surrounding valley (fig. 5).

A gently dipping bed of dolomite having an average thickness of 500 feet rests conformably on a bed of dense, fine-grained, high-calcium limestone ranging in thickness from 150 feet at the south to 75 feet at the north end. The limestone, in turn, is underlain by a dolomite formation of undetermined thickness. These formations have a general strike N. 30° W. and dip about 5° northeast. The beds have been broken by minor faults, which have caused but little displacement.

The overlying dolomite formation consists of three members. Production has been from the lowest member, which attains a thickness of 175 feet. The center member is about 70 feet thick but contains nodules and lenses of chert, which make it unsuitable as a source of dolomite. The upper dolomite member has an average thickness of 255 feet and is of the same high quality and consistency as the lowest member.

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The limestone of the Apex area comprises a series of beds having an average total thickness of 700 feet and containing thin strata of dolomite (figs. 6 and 7). The limestone is overlain by beds of dolomitic limestone, cherty dolomite, and dolomite. The formations strike N. 15° to 30° E. and dips 30° to 45° west. The quarry has been opened for a width of 200 feet in a member of the limestone formation.

The crystalline, fine-grained limestones produced at Sloan and Apex have a high-calcium content, not less than 97 percent $CaCO_3$, and are exceptionally free from siliceous material.

Characteristic analyses of the dolomite and limestone are:

Dolomite	Percent	Limestone	Percent
$MgCO_3$	42.50	$MgCO_3$	1.20
SiO_2	.25	SiO_2	.60
Fe_2O_3; Al_2O_3	.25	Fe_2O_3; Al_2O_3	.40
$CaCO_3$	57.00	$CaCO_3$	97.80
	100.00		100.00

A control laboratory is maintained at Sloan for chemically and physically testing the lime products to maintain standards of quality.

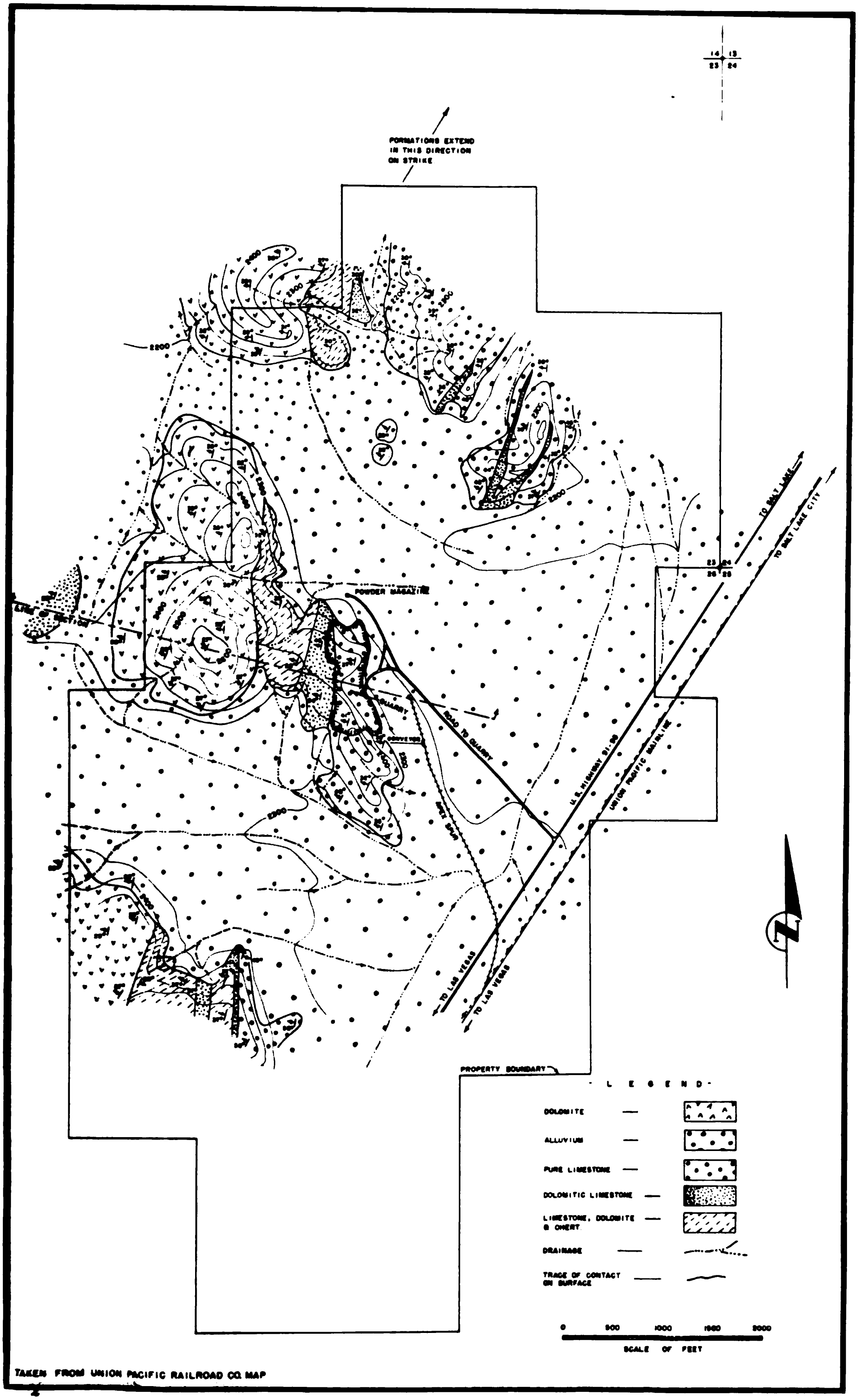
EXPLORATION

Exploration of the Sloan deposits was not necessary, as the upper dolomite formation is virtually devoid of overburden, and the limestone bed projects from the south face of the hill and forms a steep cliff. Subsequent quarrying and underground mining developed adequate reserves.

The Apex deposit was explored systematically by a series of diamond-drill holes. Ten EX holes were drilled normal to the dip of the limestone to depths up to 140 feet, proving the downward continuity of the deposit to the present quarry floor. The limestone cored well, and core recovery was high, but results were not too accurate, as core samples could not be recovered from the mud seams along the bedding planes. Drilling indicated a potential loss in fines of 10 percent, whereas actual quarrying operations have shown a loss of 25 to 30 percent. Additional diamond drilling is planned to determine the continuence of the deposit below the quarry floor.

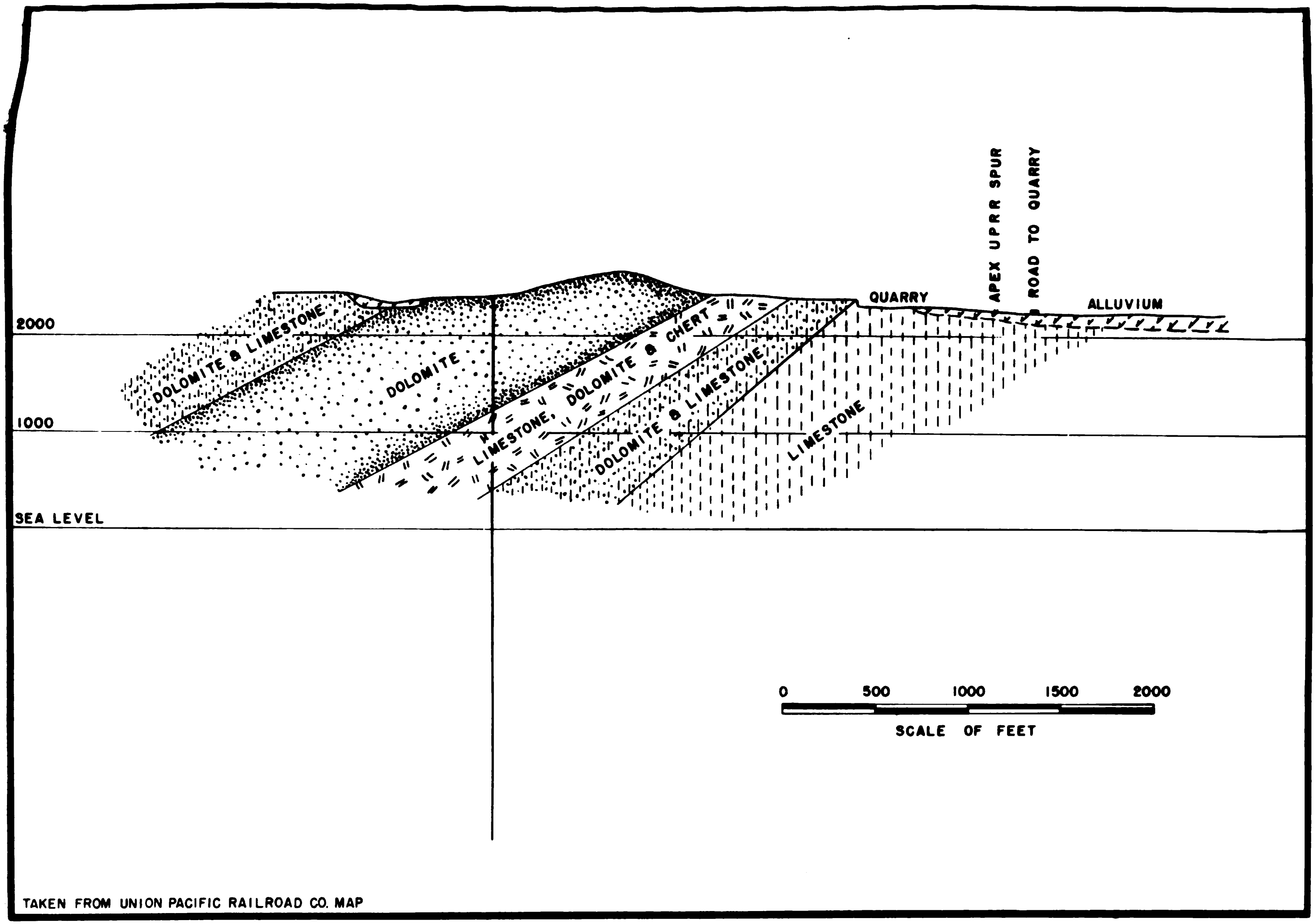
MINING METHODS

Prior to suspension of limestone production at Sloan, the deposit was mined by quarrying and shrinkage stoping. The projecting limestone formed a prominent cliff, and this could be quarried successfully with but little dilution from the overlying dolomite. As quarrying operations advanced, the amount of dolomite mined with the limestone became excessive, which made it necessary to use a new method of mining the limestone. Shrinkage stoping was the method selected (fig. 8).



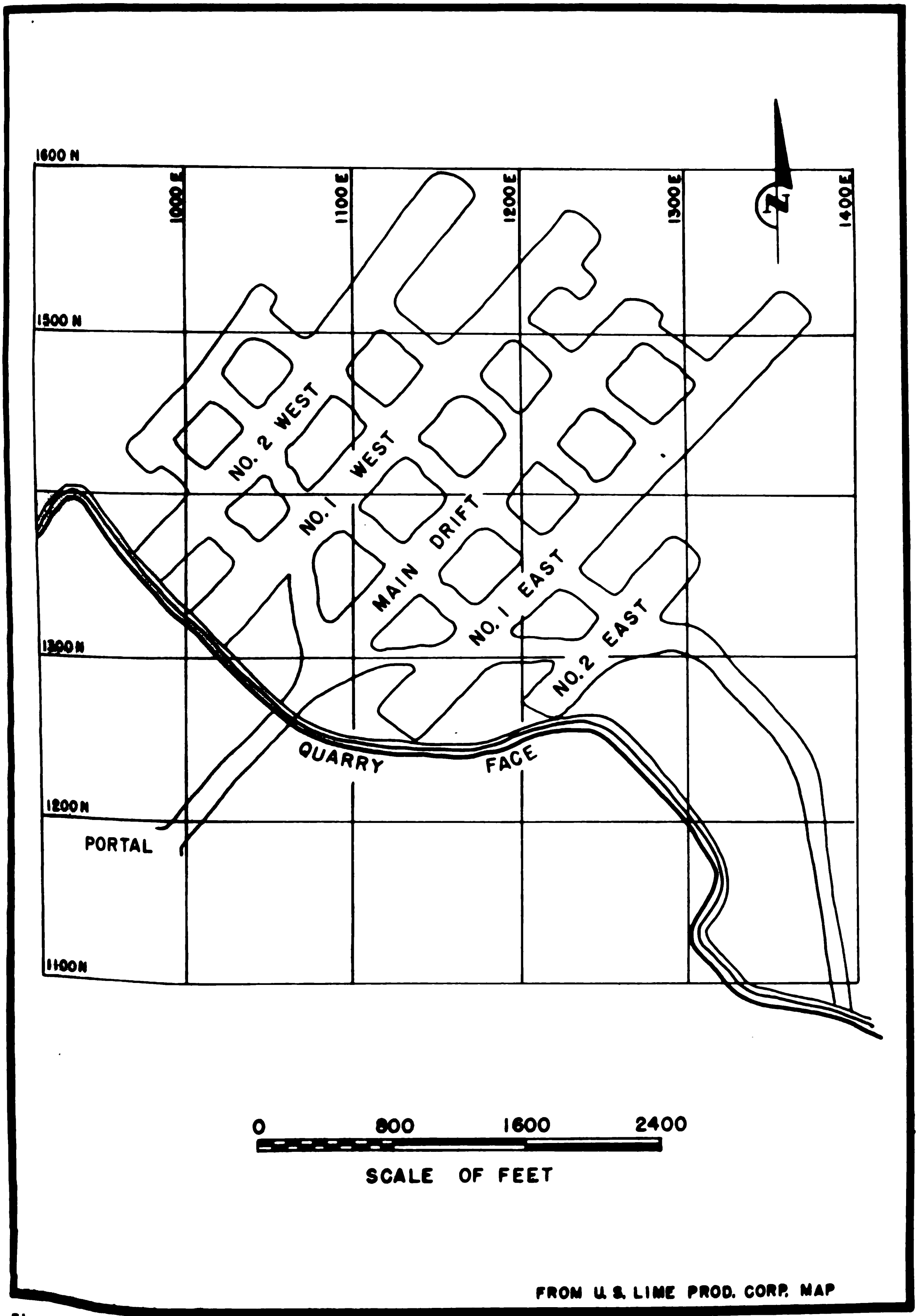
TAKEN FROM UNION PACIFIC RAILROAD CO. MAP

Figure 6. - Plan of Apex deposit, U. S. Lime Products Corp.



TAKEN FROM UNION PACIFIC RAILROAD CO. MAP

Figure 7. - Section of Apex deposit, U. S. Lime Products Corp.



FROM U. S. LIME PROD. CORP. MAP

Figure 8. - Underground workings of Sloan deposit, U. S. Lime Products Corp.

Development headings were driven into the deposit at the base of the limestone bed, with crosscuts driven at regular intervals between the drifts. The shrinkage stopes were about 30 feet wide, 80 to 100 feet high, and 250 to 300 feet long. Pillars were left between the drifts and stopes. High costs, dolomite dilution, and excessive fines produced in stoping resulted in a discontinuance in 1937 of underground mining.

Production continued until 1946 from quarries opened to the northwest along the limestone exposure. Mining was by coyote hole blasting. Tunnels about 3 by 4-1/2 feet in cross-section were driven into the limestone at right angles to the quarry faces for about 40 feet, with crosscuts from the end of these tunnels driven for 40 feet in each direction parallel to the quarry face. Black powder was placed in the crosscuts with cartridges of gelatin dynamite as a primer. The tunnel was backfilled with broken rock, and the charge was detonated electrically. From 2-1/2 to 16 tons of rock per pound of black powder was broken, dependent on the character of the ground and the angle of the face. About 40 percent of the tonnage broken required secondary blasting. Dilution with dolomite finally caused the suspension of limestone quarrying and opening of the quarry at Apex.

Dolomite is being quarried from a 300- by 100-foot pit opened to the northwest beyond a faulted section of the deposit. Some chert has been found that requires careful sorting, as shipping-grade dolomite must be low in silica and contain not less than 28 to 30 percent $MgCO_3$. Lower-grade dolomite goes to waste dumps.

The face of the pit is vertical and ranges in height from 25 to 50 feet. A row of lifters or toe holes is drilled along the bottom of the bank on 12-foot centers normal to the face, at angles of minus 5 to 10 degrees, to depths of 20 to 24 feet. A 3-inch automatic drifter mounted on a wagon drill and employing 1-inch collared hexagon drill steel in 4-foot changes is used for drilling. Detachable bits starting with the 2-1/2-inch size and with 1/8-inch changes are used. Compressed air is furnished by a 160-c.f.m., gasoline-driven, portable compressor, and 5 to 8 holes comprise a round.

Holes are sprung three times: first with 12 to 15 sticks of 40-percent gelatin dynamite, next with 25 to 30 sticks, and third with 25 to 30 pounds of 60-percent bag powder. For the final blast, holes are loaded with 300 pounds of 60-percent bag powder.

Holes are loaded by air-pressure gun, and detonation is with electric blasting caps in cartridges of 60-percent gelatin dynamite. From 4,000 to 7,000 tons of dolomite are broken per blast, averaging about 3 tons per pound of powder. Secondary blasting of large boulders is frequently necessary. The boulders are drilled with jackhamers, and the holes are loaded with gelatin dynamite. Detonation is by conventional fuse and cap. Powder, fuse, and cap costs are $0.12 per ton. The high cost is due to the small tonnage produced and the large amount of secondary blasting. Broken rock is loaded into a 6-yard-capacity dump truck by a 1-yard Diesel-driven power shovel and hauled about 1,000 feet to the crushing plant. Five workmen are required to mine, load, and transport the tonnage daily.

The open cut at Apex is about 800 feet long, 200 feet wide, and 50 to 120 feet in depth. Present breaking is along the south end of the cut to a 90-foot bank. The physical characteristics of the limestone permit maintaining vertical faces.

Toe holes are drilled on 17-foot centers along the base of the bank normal to the face to a depth of 36 feet. A parallel row of breast holes is drilled 6 feet above the lifters to depths of 25 to 30 feet. Toe holes are inclined 10° to 15° downward, and breast holes are inclined 10° to 15° upward, designed so the ends of the holes will be about 25 feet apart vertically.

Drilling is done with a wagon drill mounting a 4-inch drifter and using 1-1/4-inch, hollow, round steel in 6-foot changes. Detachable bits are used, starting with a 3-inch size and with successive 1/8-inch changes. The nonabrasive character of the limestone makes for long bit life. Bits will average 300 feet of drilling before losing gage. Compressed air is supplied from a two-stage, 360-c.f.m., stationary, Diesel-driven compressor with 4- by 9-foot air receivers at the compressor house and quarry. Four to six weeks are required to complete a round and prepare the holes for the final blast; 8 to 15 holes usually constitute a round.

The drill holes are sprung an average of five times - four times with ten to twenty 1-1/4- by 8-inch cartridges of 60-percent gelatin dynamite. The cartridges are placed in the bottom of the hole and detonated with electric blasting caps. Holes are allowed to cool for 1 day between shots. The fifth time, 100 pounds of 60-percent bag powder is loaded in the hole and detonated with an electric primer in a cartridge of 60-percent dynamite.

The holes are loaded by air-pressure gun with 300 to 600 pounds of 40-percent bag powder on completion of springing. Detonation is by No. 12 delay electric blasting caps in cartridges of 60-percent gelatin dynamite. Toe and breast holes are fired simultaneously. A round will break an estimated 30,000 to 35,000 tons of limestone, or an average of 10 tons per pound of powder. Cost of powder and caps is $0.05 a ton.

The round breaks clean, and the face is usually free of loose slabs. Loose pieces of overhanging rock are brought down from the face by using an industrial gun. This gun was originally developed to shoot out clinker rings in lime and cement kilns, and its use at the Apex quarry is unique. It weighs 92 pounds, uses an approximate 8-gage shell, and fires a 3-ounce lead slug at a muzzle velocity of over 1,600 feet per second. The gun is mounted on an I-beam attached behind the cab of a 1-1/2-ton truck (figs. 9 and 10).

Its use in dislodging loose rocks from quarry faces and the high muck piles lessens the danger from falling rock and makes for greater safety. Nonproductive shovel time is reduced as the slow and hazardous job of scaling and barring down is eliminated.

Some blockholing is necessary, but large slabs and rocks are broken with a rock breaker. A 3/4-yard, Diesel-driven shovel equipped with a 40-foot

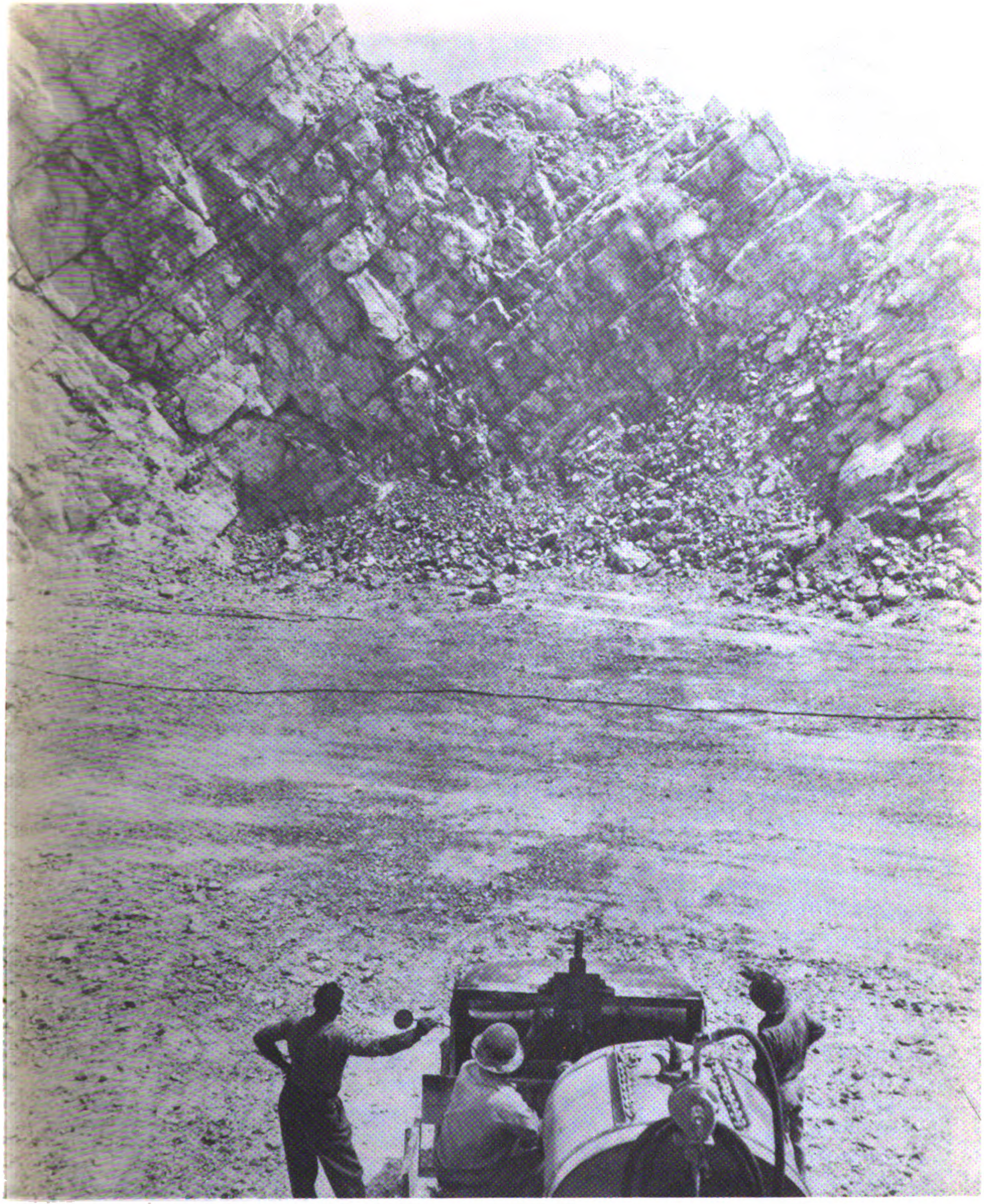


Figure 9. - Industrial gun in action. Apex quarry, U. S. Lime Products Corp., looking north.

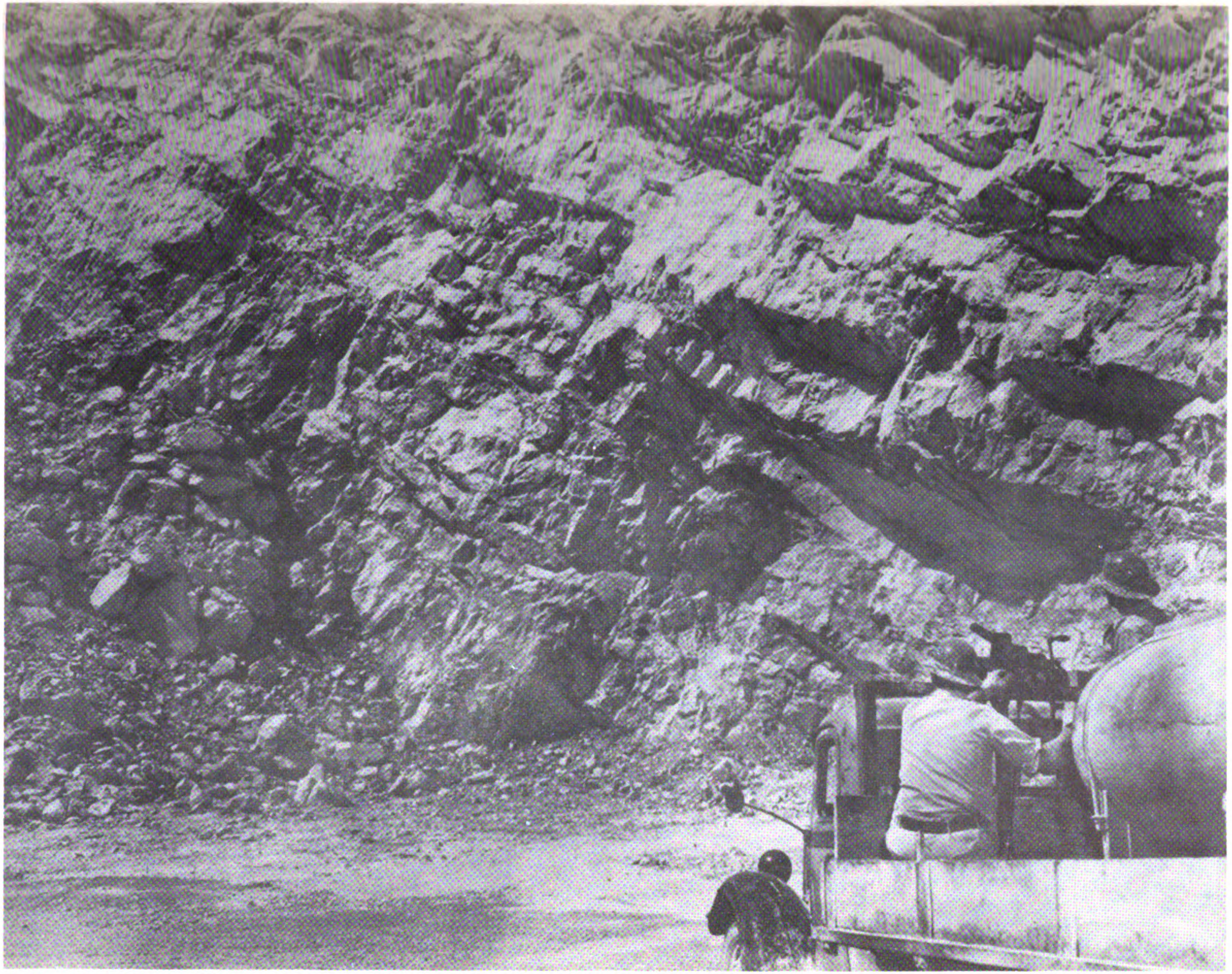


Figure 10. - Industrial gun mounted on truck. Apex quarry, U. S. Lime Products Corp.

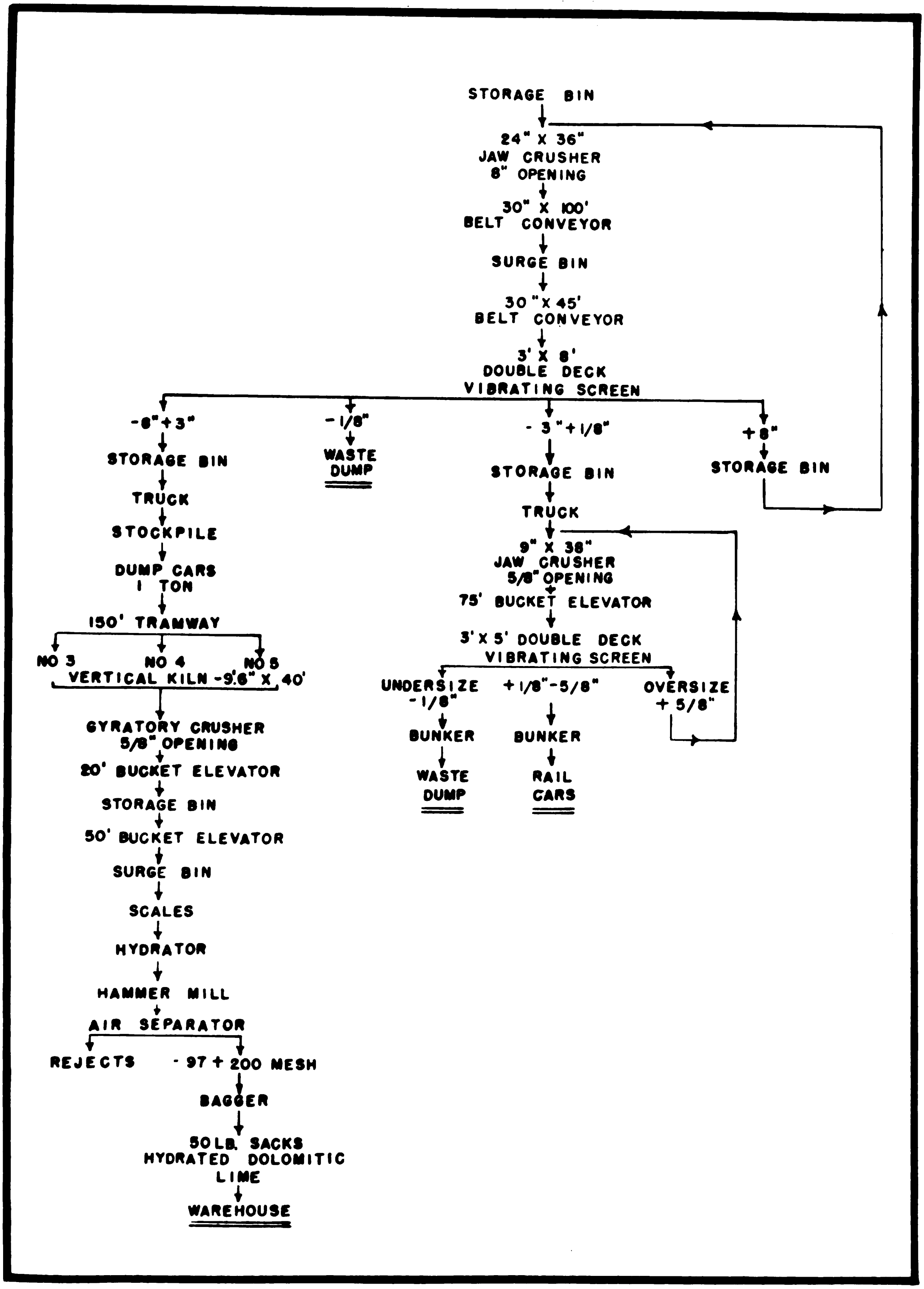


Figure 11. - Flow sheet of the crushing plant and dolomite section, Sloan mill, U. S. Lime Products Corp.

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dragline boom handles a 2,500-pound, pear-shaped breaking ball. The breaker moves in close to the muck pile and shovel, efficiently breaking boulders and slabs too large to be handled by the shovel. Its use further cuts down nonproductive shovel time.

Broken limestone is loaded by a 1-1/2 yard, Diesel-driven power shovel into two 6-yard- and one 8-yard-capacity dump trucks and hauled about 700 feet to the crushing plant.

Equipment

Mining, loading, and hauling equipment used in the Sloan quarry comprise:

1 Ingersoll-Rand wagon drill equipped with L74 drifter.
1 Ingersoll-Rand, 160-c.f.m., portable, gasoline-driven compressor.
1 Lorain, 1-yard, Diesel-driven power shovel.
1 Caterpillar D4 tractor equipped with a Southwest 3/4-yard scoop shovel.
1 International K-7, 6-cu. yd.-capacity dump truck.
1 Wilson 200-amp., portable, electric welder.

Mining equipment at the Apex quarry comprises:

1 Ingersoll-Rand Model FM2 wagon drill.
1 Ingersoll-Rand type 40, 2-stage, 360-c.f.m. compressor driven by an International UD-18 Diesel engine.
1 Northwest No. 6, 1-1/2-yard power shovel equipped with a Murphy Diesel engine.
1 Lorain, 3/4-yard, Diesel-driven power shovel equipped with a 40-foot dragline boom and a 2,500-pound breaking ball.
1 International KR11 8-cu. yd.-capacity dump truck.
1 International KR10 6-cu. yd.-capacity dump truck.
1 International KR8 6-cu. yd.-capacity dump truck.
1 International TD14 tractor equipped with a Bucyrus-Erie bulldozer.
1 Remington industrial gun.
1 Trojan air-powder loader.
1 200-amp., Wilson, electric welder mounted on an International D40 truck. Ingersoll-Rand type 2 C. H. jack bits.

CRUSHING PLANTS

Broken dolomite from the Sloan pit is delivered by truck to the primary crushing plant (fig. 11). The rock is crushed in a jaw crusher set to an 8-inch opening, passed to a belt conveyor, and carried to a surge bin. It then passes over a second belt conveyor to a double-deck, horizontal, vibrating screen fitted with 3-inch and 1/8-inch screens. The minus 8 plus 3-inch product is trucked to a stock pile for calcining; the minus 3 plus 1/8-inch is trucked to the secondary crushing plant; the minus 1/8-inch product goes to waste.

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A 75-h.p. Diesel engine drives the primary jaw crusher, and a 25-kw. Diesel generator supplies power to the conveyor-belt motors. The crushed dolomite is hauled to the stock piles in a 10-ton dump truck.

The secondary crushing plant further reduces the minus 3 plus 1/8-inch dolomite product in a secondary jaw crusher. This product passes to a bucket elevator and over a double-deck, horizontal, vibrating screen equipped with 5/8-inch and 1/8-inch screens. The minus 5/8 plus 1/8-inch product is loaded in railroad cars for shipment to steel mills; oversize plus 5/8-inch rock is returned to the secondary crusher and reprocessed through the plant; and the minus 1/8-inch product goes to waste. Some of the waste, however, has recently been shipped to Los Angeles for use in the manufacture of rock-wool products. Secondary crushing-plant equipment is motor-driven.

At the Apex plant, broken limestone is dumped from trucks into a coarse-ore bin and fed to a jaw crusher set with a 6-inch opening (fig. 12). The crusher is driven by a 125-h.p. Diesel engine. The product passes over a belt conveyor to a double-deck, horizontal, vibrating screen fitted with 1-1/2-inch and 1/4-inch screens. The minus 6 plus 1-1/2-inch and minus 1-1/2 plus 1/4-inch products pass over a belt conveyor to a surge pile. The minus 1/4-inch product goes over a belt conveyor to waste.

The crushed limestone is fed from the surge pile to a belt conveyor by a vibrator feeder. The conveyor transports the rock to a single-deck, horizontal, vibrating screen with 2-3/4-inch openings. The minus 6 plus 2-3/4-inch product goes to two loading bins. It is then passed over a 2-inch grizzly and is loaded in railroad cars for shipment to sugar factories and steel mills. The minus 2 inch product from the grizzly passes to a cross-conveyor belt and is fed to the return conveyor from the secondary crusher.

The minus 2-3/4 plus 1/4-inch rock drops to a double-deck, horizontal vibrating screen with 1-1/2- and 1/2-inch screens. The minus 2-3/4 plus 1-1/2-inch product goes to a secondary jaw crusher, the crushed product being returned by belt conveyor to the circuit. This procedure eliminates fines and the use of bucket elevators.

The minus 1-1/2 plus 1/2-inch product, known as kiln-rock size, passes to the loading bins for shipment in railroad cars to steel mills or to the Sloan and Henderson calcining plants. The minus 1/2-inch product goes to waste.

Stock piles of minus 6 inch plus 1/4-inch and minus 1-1/2 inch plus 1/2-inch sizes are maintained. The latter product can be returned to the circuit over a belt conveyor.

Recently, the minus 1/4- and minus 1/2-inch waste products have been shipped to consumers for use in the manufacture of building blocks, chemicals, rock wool, and for road surfacing.

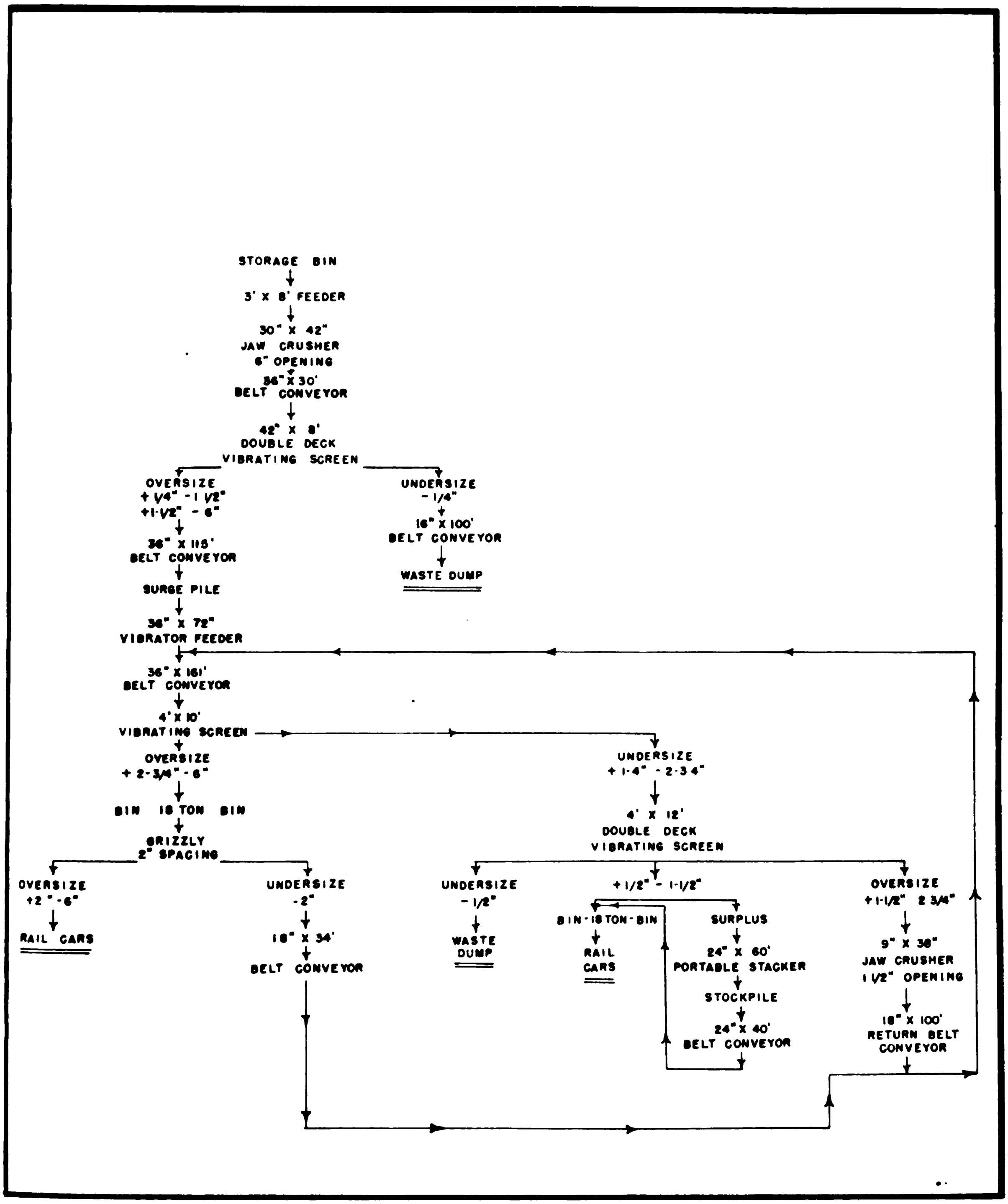

Figure 12. - Flow sheet of the Apex crushing plant, U. S. Lime Products Corp.

Equipment - Crushing Plants

Sloan:

Traylor primary jaw crusher, 24 x 36 inches.
Caterpillar-Diesel engine, 75 h.p.
International-Diesel generator, 25 kw.
Niagara 3 x 8-foot, double-deck vibrating screen
International K-10, 10-ton dump truck
Pacific Alloys secondary jaw crusher, 9 x 38 inches
Cottrell 3 x 5-foot, double-deck vibrating screen

Apex:

Traylor 3 x 8-foot feeder.
Pioneer primary jaw crusher, 30 x 42 inches.
Caterpillar-Diesel engine D13000, 125-h.p.
Symons, 42 inches x 8 foot double deck vibrating screen
Jeffrey Type 5 vibrator feeder, 36 x 72 inches
Allis-Chalmers 4 x 10-foot, single-deck, vibrating screen
Allis-Chalmers 4 x 12-foot, double-deck, vibrating screen
Alloy Steel & Metals secondary jaw crusher, 9 x 38 inches
Tulsa electric-winch car puller

CALCINING AND MILLING PLANTS

Sloan dolomite section

Crushed dolomite, minus 8 plus 3-inch, is trucked from the stock pile to an ore bin, loaded in gable-bottom dump cars, and hoisted over an inclined tramway to the top of three vertical kilns (fig. 11). Each kiln has a capacity of 50 tons. Two units are in continuous operation, a third unit, being held as a standby. The dolomite is burned for 4 hours at 2,400° F. and then pulled. Kilns are oil-fired; preheated steam is used to atomize the oil. Fuel-oil consumption is 0.9 barrel per ton of dolomitic quicklime produced, and daily production of each kiln is 12 to 15 tons of burned dolomite from 30 tons of rock.

Dolomitic quicklime is reduced in a gyratory crusher and hoisted to storage bins. It is then passed over weighing scales and fed to a 1-ton-capacity batch hydrator and mixed with a measured amount of water. The hydrated product is pulverized in a hammer mill in closed circuit with an air separator, and is passed to a bagging machine, which fills 50-pound sacks with the finished product. The following is an average analysis of the hydrated lime:

	Percent
$Ca(OH)_2$	66.20
MgO	31.80
SiO_2	.25

	Percent
R_2O_3	.25
H_2O free	.75
CO_2	.75

Screen analysis:

	Percent
100 mesh	100.00
200 mesh	98.00

Sloan Limestone Section

Crushed limestone, minus 1-1/2 plus 1/2 inch size, from the Apex quarry is dumped from railroad cars into a loading pit and passed over a belt conveyor to a surge pile. A 10 ton dump truck hauls the rock to a bucket elevator which carries it to two circular steel storage bins above the kilns. (Fig. 13).

Limestone is fed by gravity and burned in two 100-foot-long, rotary, oil-fired kilns. The larger kiln is 8 feet in diameter; the smaller has a diameter of 6 feet at the cold end and 7 feet at the hot end. The cold ends are lined with 45 percent alumina, hard-pressed fire bricks made to stand rock abrasion, and hot ends are lined with a 70-percent alumina, hard-pressed, heat-resistant fire brick. Both kilns are motor-driven through a variable-speed transmission at speeds averaging 4-1/2 minutes per revolution for the large kiln and 3-1/2 minutes for the smaller. Kilns are oil-fired, preheated steam being used to atomize the oil. Oil consumption is 1.6 barrels per ton of quicklime produced. Heat is controlled by means of an optical pyrometer and is maintained at 2,600° F. Joint capacity is 220 tons of raw limestone daily, producing 120 tons of quicklime. Kilns average a year's operation before requiring repairs or patching.

Steam is produced in two 50-h.p., oil-fired boilers, one of which is used as a standby. Daily oil consumption is 13 barrels.

The calcined product is discharged into a hot pit, hoisted by a bucket elevator, and fed into two rotary coolers. One is 3 feet in diameter and 42 feet long; the other is 5 feet in diameter and 50 feet long. A bucket elevator elevates the material where it passes through a revolving trommel. The oversize is discharged into four bulk quicklime storage bins and the undersize goes to a hydrate storage bin.

Bulk quicklime is loaded directly into railroad cars or trucks with a motor-driven boxcar loader or is reduced in a gyratory crusher and elevated to storage bins. It is then fed to a hammer mill in closed circuit with an air separator. The pulverized product passes to a bagging machine and is

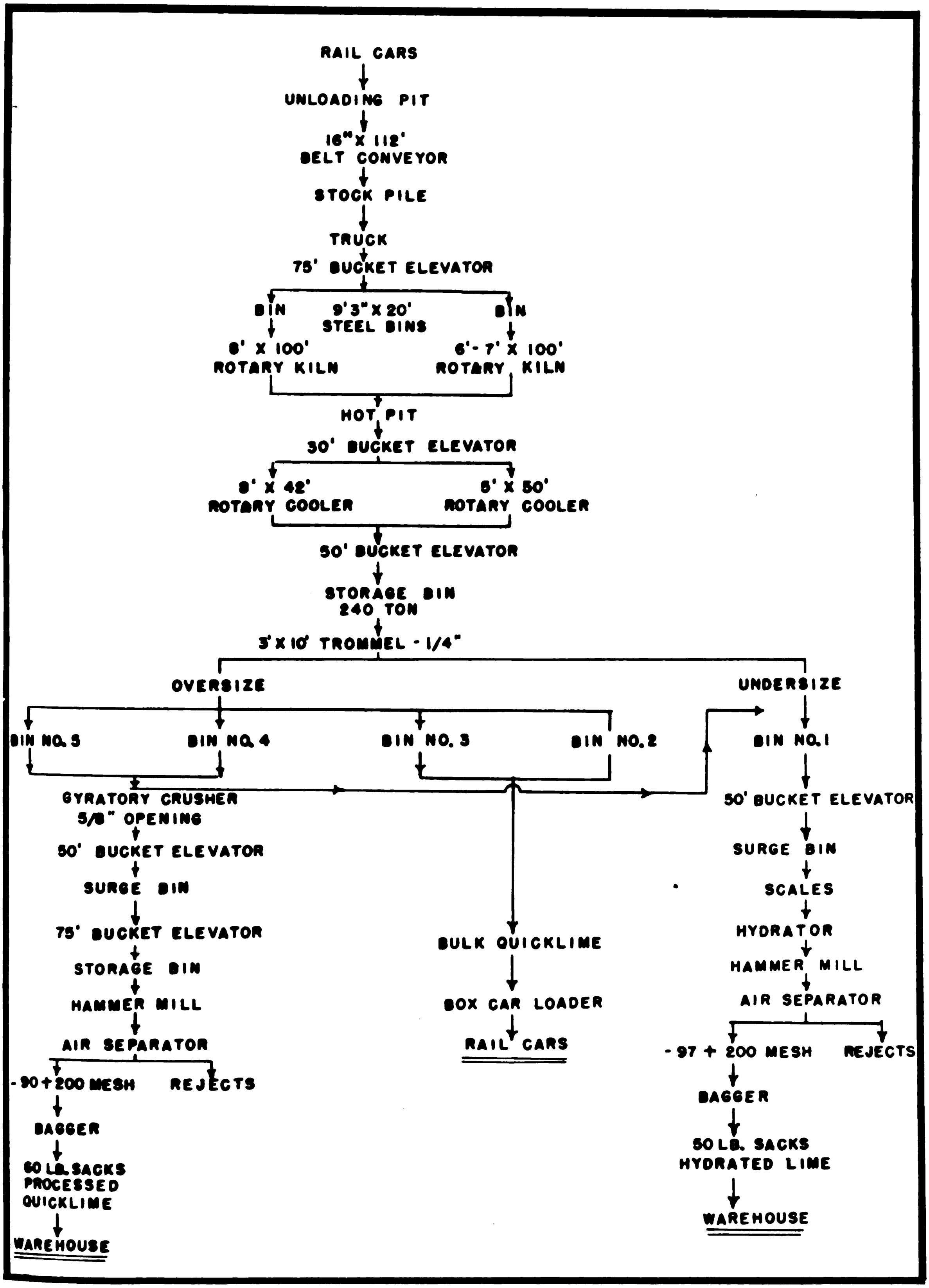

Figure 13. - Flow sheet of the limestone section, Sloan mill, U. S. Lime Products Corp.

sacked in 60-pound bags. A typical analysis of the finished product, processed quicklime, is as follows:

	Percent
CaO	96.60
MgO	1.10
Insol.	1.10
R_2O_3	.70
SO_3	.03
Ign. loss	.47

Pebble lime from the hydrate bin is passed to a batch hydrator, mixed with a measured amount of water, and pulverized in a hammer mill in closed circuit with an air separator. The product is passed to a bagging machine, which fills 50-pound sacks with hydrated lime. An analysis of the hydrated limes follows:

	Percent
$Ca(OH)_2$	97.05
MgO	1.00
SiO_2	.40
R_2O_3	.15
H_2O-free	.50
CO_2	.90
CaO equivalent	74.00
Screen analysis:	
100 mesh	100.00
200 mesh	97.50

Hydrating and bagging equipment is belt-driven by a 150-h.p. Diesel engine. Pulverizing equipment is belt-driven by 75-h.p. Diesel engine.

Equipment

Sloan milling equipment comprises:

1 F. M. 150-h.p. Diesel engine
1 Cummins 75-h.p. Diesel engine
1 Sturtevant gyratory crusher
1 Clyde hydrator
2 Raymond hammer mill
2 Raymond cyclone air separator
2 Bates bagger
1 Stephens-Adamson Sinden boxcar loader
1 Wilson portable electric welder, 200 amp.
1 Ingersoll-Rand, ER1, 9 x 8 inch, stationary air compressor

Henderson Plant

An additional calcining unit was put into operation during November 1948 at the Basic Magnesium, Inc., plant at Henderson to augment the supply of bulk quicklime (fig. 14). High-calcium limestone is hauled via Union Pacific Railroad from the Apex plant to Henderson.

Crushed rock is dumped from railroad cars into a hopper and passes over a belt conveyor to a storage bin. It is then carried by belt conveyor to a surge tank and fed to a 6-1/2- by 100-foot, oil-fired, rotary kiln. The calcined product is dropped to a 5- by 50-foot rotary cooler, passed to a hot-lime belt conveyor, and elevated over an inclined belt conveyor to a single-deck vibrating screen equipped with a 1/8-inch screen. The undersize passes to a fines bin, and the oversize is carried over a reversible belt conveyor to four 100-ton storage bins. The bulk quicklime is fed from the storage bins to a cross-belt conveyor, dropped on an inclined belt conveyor, and loaded in rail cars.

Fuel oil under pressures of from 200 to 300 p.s.i. is combined with air from a low-pressure blower and fed to the rotary kiln. Kiln temperature is maintained at 2,400° F., controlled by electric pyrometers and the rotation of the kiln, which is regulated through a variable-speed transmission. A mechanical blower at the cold end pulls combustion gases through the kiln and forces them up the exhaust stack. The rotary cooler is water-cooled.

Daily production is 50 to 60 tons bulk quicklime from 110 tons of limestone.

COSTS

The following costs of main operating supplies were supplied by the company:

Comparative fuel-oil costs, f.o.b. Sloan:

	1940	1948
Fuel oil, bbl.	$0.65	$2.30
Freight	.95	1.25
	1.60	3.55
Cost per gallon	0.038	0.085

Comparative Diesel-oil costs, f.o.b. Sloan:

Cost per gallon	0.0525	0.115

Comparative explosives costs show:

40-percent bag powder, per 100 lb.	10.75	14.25
60-percent bag powder, per 100 lb.	12.00	14.65

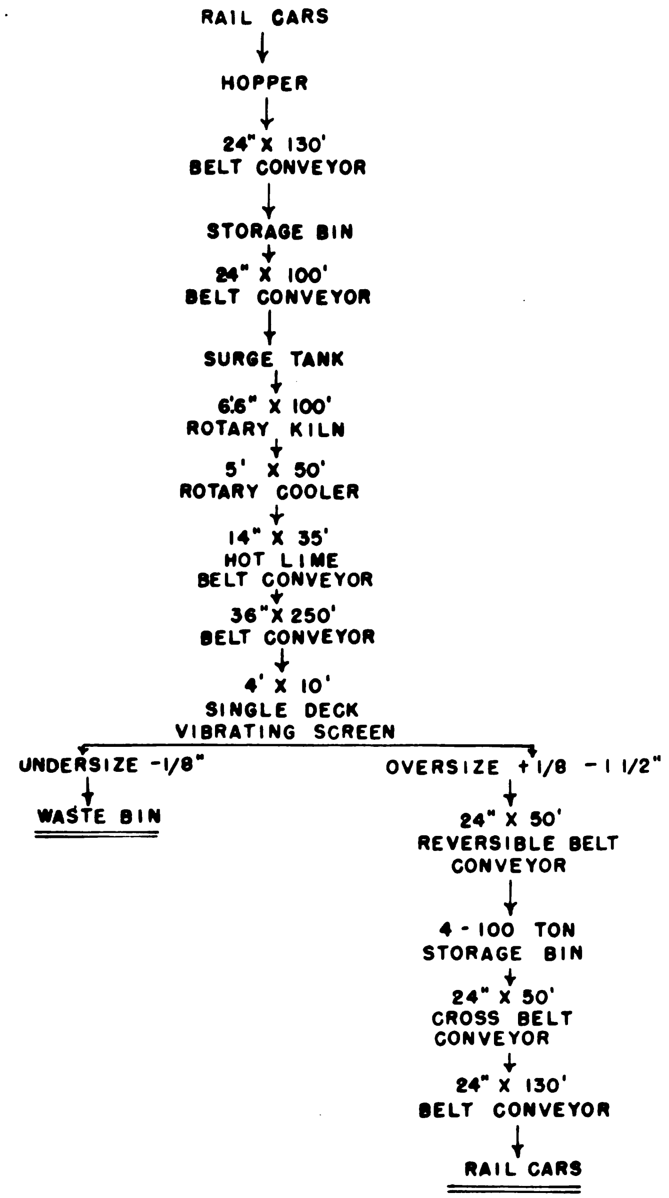

Figure 14. - Flow sheet of the Henderson calcining plant, U. S. Lime Products Corp.

	1940	1948
60-percent gelatin powder, per 100 lb.	$13.25	$15.25
No. 6 blasting caps, per 1,000	14.75	16.25
No. 12 electric blasting caps, per 100	17.50	43.00
Fuse, per 1,000 ft.	6.10	10.40

COMPARATIVE WAGE SCALES

Labor classification, prevailing and comparative hourly wage scales at the Sloan, Apex, and Henderson plants, are:

	1941	1948
Sloan rates:		
Kiln burner	$0.65	$1.455
Kiln burner helper	.65	1.32
Hydrator operator	.75	1.395
Maintenance man	.75	1.445
Crusher operator	.60	1.195
Jackhamer operator	.70	1.245
Truck driver	.80	1.35
Laborer	.56	1.145
Shovel operator	.90	1.665
Packers	.46	1.245
Apex rates:		
Jackhamer operator	1.00	1.365
Wagon-drill operator	1.25	1.565
Crusherman	1.00	1.415
Truck driver	1.055	1.425
Shovel operator	1.35	2.05
Mechanic	1.20	1.775
Laborer	1.00	1.315

	Present rates
Henderson rates:	
Loadman	$1.70
Kiln burner	1.575
Kiln burner helper	1.475
Laborer	1.275

Time and one-half is paid for work in excess of 40 hours weekly, and double time for the seventh consecutive day.

Railroad-car and truck loaders are now on a contract basis, receiving $0.24 per ton for loading bulk material and $0.28 per ton for loading the 50- and 60-pound sacks.